MINEROLOGICAL CHARACTERIZATION OF LUNAR NEAR SIDE CARDANUS AND KRAFFT CRATERS. Eaineesh Pundir1, Koyel Sur1, Vipan Kumar Verma1, Mamta Chauhan2, Prakash Chauhan3, Joyita Thapa, Brijendra Pateriya1 Punjab Remote Sensing Centre, Ludhiana1, Indian Institute of Remote Sensing, Dehradun2, National Remote Sensing Centre, Hyderabad3, Asutosh College(University of Calcutta)4. Corresponding author: koyelsur3@gmail.com

Introduction: Lunar craters are the most common features present on the surface of the Moon. With negligible atmospheric presence, formation of these craters on the Moon may be attributed to the unrestricted bombardment of different meteors and asteroids on its surface along with volcanism over the course of time [1]. During impact sub-surface material get excavated and ejected on and near the crater surface. Hence, these craters are no less than a goldmine for researchers aiming to characterize the subsurface lunar geology.

The main aim of this study is mineralogical characterization of the two lunar impact craters namely-Cardanus (13.2°N, 72.4°W) and Krafft (16.6°N, 72.6°W); which are located on the western side of the Oceanus Procellarum as shown in Figure 1. The two craters are visible from the earth and are joined by a series of small craters (Catena chain).

Figure 1: (a) Location of study areas as shown in the colour coded LOLA elevation globe; (b) Selene Orthoimages showing closeup view of craters, Cardanus (b.1) & Krafft (b.2); (c) location in mosaicked Ch-1 M3 data.

Data: ISRO’s Chandrayaan-1 carried NASA’s Moon Mineralogy Mapper (M3) sensor that provides hyperspectral datasets. These datasets were, obtained from the NASA Planetary Data System, and were used for characterizing the mineralogy of the craters. Prior to analysis, Ch-1-M3 Level 2 reflectance products were seleno-referenced using the corresponding location files associated with the Level 1 radiance product and then mosaicked to generate the hyper-spectral data cube for the whole study area.

Results & Discussion: Several band ratio techniques were utilized for obtaining the spatial distribution of the different minerals in the study area. These techniques mainly focuses on highlighting the areas having absorption in the 1 & 2µm bands which serve as the main factor in recognizing the mineralogy of the area. Olivine and pyroxene show characteristic absorption in 1 µm and both 1 & 2 µm bands respectively whereas spinel shows absorption in 2 µm band. False color composite using the pyroxene, spinel and pure anorthosite (PAN) ratio is computed which indicates the possible presence of the corresponding minerals as shown in Figure 2(a). Pyroxene is shown in red to orange colors, spinel is shown in cyan to green colors whereas the blue color shows the anorthosite highland materials. Rims of both the craters are shown in green to cyan colour which indicates a mixed mineralogy.

Integrated Band depth (IBD) is also computed for the 1 & 2µm wavelengths which also helps in detecting the presence of different minerals in the area. Figure 2(b) shows the IBD False color composite where red, green and blue bands shows IBD 1000, IBD 2000 & reflectance at 1489 nm respectively. Yellow to yellowish green color shows mare basalts whereas blue color denote the highland mafic features.

Table A: Different parameters and band ratios used for hyper-spectral data processing (R-Reflectance and Rc-Continuum removed Reflectance).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
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<tbody>
<tr>
<td>Pyroxene ratio</td>
<td>(R700+R1200)/(2*R950)</td>
</tr>
<tr>
<td>Spinel ratio</td>
<td>(R1400)/(R1750)</td>
</tr>
<tr>
<td>PAN ratio</td>
<td>(R1000+R1500)/(2*R1250)</td>
</tr>
<tr>
<td>IBD 1000 n ∈ [0,26]</td>
<td>$\sum [1 - (R789+20n)/(Rc789+20n)]$</td>
</tr>
</tbody>
</table>
Figure 2: (a) False Color Composite (R: Pyroxene Ratio, G: Spinel Ratio, B: PAN ratio), (b) IBD False Color Composite (R: IBD 1000, G: IBD 2000, B: Reflectance at 1489 nm)  

Sub-classification of the different pyroxene spectra have been done by observing the absorption band centers at 1 & 2µm wavelengths. Position of the absorption bands centers at 1 & 2µm (BC1 & BC2) is computed for the different pyroxene bearing samples from the bright young craters in and around the study area. The BC1 values are plotted against BC2 values along with the previously reported values in various publications which include both pure and synthetic ortho and clino pyroxenes (OP & CP) [2, 3, 4]. Figure 3 shows the combined BC1 vs BC2 plot for current as well as previously reported observations. The position of the observed band centers clearly coincides with the clino-pyroxene samples which suggest that the pyroxenes are dominated with the presence of clinopyroxene.

Conclusion: The detailed mineralogical assessment has been done for the Cardanus & Krafft craters. The different band ratio techniques along with the comparative analysis of absorption band centers indicates the presence of mixed minerology in the area dominated by clinopyroxene and spinel.

Figure 3: Band Center 1 vs Band Center 2 plot for the two crater (marked by red cross and blue cross) along with the previous reported observations

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References: